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BIOLOGICAL EVALUATION

DOUGLAS-FIR TUSSOCK MOTH

OREGON AND WASHINGTON 1972-1973

U.S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
Division of Timber Management
Region 6
Portland, Oregon

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Introduction

In 1971, after several years of dormancy, the Douglas-fir tussock moth became active in Washington and Oregon. The intensity of defoliation by this moth increased during the summer of 1972 and several very visible outbreak centers developed, although damage was previously visible in only three small areas in Washington. Additional areas of potential defoliation, indicated by the presence of large numbers of unhatched eggs, were located through a survey conducted in the fall of 1972.

Entomological evaluation surveys, reported on in this section, were undertaken during the fall of 1972 in known Douglas-fir tussock moth activity centers and in adjacent areas of host-type timber. The primary objectives of these surveys were to: locate and delineate areas where the tussock moth was active; measure the density and trend of the moth population in these areas; and collect egg masses from which the incidence of a virus disease in the moth population might be determined.

In excess of 100 individuals from many organizations were involved in making the surveys and evaluating the data collected. David McComb, Entomologist, Insect & Disease Control, Region Six, USFS, coordinated the surveys and evaluation of the data collected. LeRoy Kline, Entomologist from the Oregon Department of Forestry and Rick Johnsey, Entomologist from the Washington State Department of Natural Resources assisted in the training and supervision of the crews collecting the data. Survey crews were supplied by the Oregon Department of Forestry, Washington State Department of Natural Resources, Colville Indian Agency, Boise Cascade Corporation, and the Wenatchee, Okanogan, Umatilla and Wallowa-Whitman National Forests. T. F. Gregg, Forestry Technician from the Insect & Disease Control Branch, Region Six, USFS, made the helicopter surveys. Richard Mason, Insect Ecologist from the Pacific Northwest Forest and Range Experiment Station developed the sequential sampling method used in the egg density surveys. The Insect Disease Research Work Unit, under the direction of Dr. C. G. Thompson at Corvallis, Oregon, prepared the guidelines for collecting eggs to determine the presence of virus in the moth population and is presently involved in rearing the moths required for determination of the incidence of this disease. Under the direction of Boyd Wickman, the Insect Population Dynamics Research Work Unit of the PNW Station at Corvallis evaluated the size of the tussock moth eggs collected during these surveys. All of the above were active in planning the surveys and consulted in evaluating the data collected.

Causal Agent

Common name - Douglas-fir tussock moth
Scientific name - Hemerocampa pseudotsugata McDonnough

Host Trees

The two species of trees on which the defoliation by the tussock moth has been heaviest and which can be considered its preferred host in the current infestation are:

Douglas-fir - Pseudotsuga manziesii var. menziesii
Grand fir - Abies grandis

Other tree species in the infested area on which the tussock moth has been feeding and defoliating to a lesser degree are:

Subalpine fir - Abies lasiocarpa
Engelmann spruce - Picea engelmannii
Ponderosa pine - Pinus ponderosa
Western larch - Larix occidentalis
Western hemlock - Tsuga heterophylla

Damage

Newly hatched larvae crawl to the ends of the branches and feed on new foliage. While these needles are not consumed, the feeding along the rib on the underside of the needle causes it to shrivel, turn brown and fall off later in the year. As the larvae mature they turn to feeding on both old and new foliage and consume the entire needle.

The killing of the new foliage by the small larvae is both rapid and devastating in appearance. This may be misleading as the loss of only the current year's foliage may not be of vital importance unless it is on trees where defoliation occurred the previous year, in which case, the loss of only the current year's growth is usually of paramount importance.

As the larvae mature their rate of feeding increases. When large populations of the moth larvae are actively feeding, entire trees may be stripped of all foliage in a few weeks. When all foliage has been consumed the caterpillars crawl to adjacent trees where feeding continues until the larvae reach the state where they pupate.

Complete or near complete defoliation of a tree results in death while defoliation of a lesser degree often results in top kills and retardation of tree growth.

Current Outbreak History

The last tussock moth outbreak on record in Oregon and Washington was during 1965 when 66,000 infested acres in the Malheur and Ochoco National Forests in central Oregon were sprayed with DDT from helicopters to control part of the outbreak. Later that summer, two new centers of light to moderate defoliation developed on the Fremont National Forest in southern Oregon and a small infestation continued at a low level in northeastern Washington. New to old egg mass ratio surveys made later that year showed a definite downward trend in both states. Extensive surveys for egg masses did not locate any new egg masses in the fall of 1966.

During 1966, 30 annual defoliator monitoring survey plots were established in true fir and Douglas-fir stands in eastern Oregon. The primary objective of these survey plots was to detect low-level population fluctuations of the Douglas-fir tussock moth and other defoliators. Four additional plots were established in 1970. No Douglas-fir tussock moth larvae were collected on these plots until 1970.

Aerial insect detection surveys of the entire timbered areas in Oregon and Washington are made annually. During the period from 1966 through 1969 no damage from the tussock moth was observed or reported.

During the spring of 1970, 19 tussock moth larvae were found on the defoliator monitoring plots in eastern Oregon. Collection counts on these plots in 1971 increased to 84 but no visible defoliation was recorded in Oregon during the annual aerial insect detection surveys.

In the summer of 1971 severe defoliation of Douglas-fir occurred at several widely scattered locations on the Wenatchee and Okanogan National Forests in Washington. Extensive top killing and tree mortality occurred on 1,500 acres of National Forest and private land near Cashmere, Washington. Surveys in this area revealed that most of the moth population had died in the late larval instars during August of 1971. Dead larvae were collected and sent to the Oregon State University Department of Agricultural Chemistry where Dr. Robert Claey's analysis showed 0.38 parts per million DDT, 0.38 parts per million DDE, and 0.23 parts per million lindane. It was the opinion of Dr. Logan Norris, Chemist in charge of the Forest Chemicals Research Work Unit, that the concentrations of DDT, DDE, and lindane found were sufficient to cause mortality of the tussock moth. Whether the entire area was actually treated could not be established.

New to old egg ratio surveys made during the fall of 1971 indicated that the infestations at Riverside and Oroville in north central Washington would be active and expanding in 1972. Plans were then made to use these two areas for the field testing of DDT-substitute insecticides that showed promise for tussock moth control.

Egg hatch in these two areas occurred early in June of 1972 and by late June, when the test insecticides were applied, the Douglas-fir foliage had turned brick red as a result of new needle destruction. In addition to these areas of known infestations, defoliation was also observed at Lake Wanacutt, Lake Wenatchee, in the hills west of Oroville, at many small areas on the Colville Indian lands, and in several small pockets of timber in draws on the south side of Lake Roosevelt.

Tussock moths were found on 10 of the 13 annual defoliator monitoring plots between La Grande and Pomeroy in the northeastern Oregon-southeastern Washington area. Larvae counts on this series of plots jumped from 79 in 1971 to 468 in 1972. Firs along the Grande Ronde Valley were noticeably off-color by the end of June, and by late July, Douglas-fir and true fir stands between Pomeroy and La Grande had turned red as though a forest fire had run through them. In many areas the ground was covered with a layer of frass dropped by the feeding larvae. On several thousand acres the trees had been completely stripped of all foliage and the ground was covered by larvae traveling in search of a new supply of food. Pupation started in late July and by mid-August the emerging moths started to lay eggs. In many areas, cocoons and egg masses hung like bunches of grapes on the denuded branches of the firs.

It was during this period in the history of the outbreak that a committee of private, state, and federal foresters and entomologists was appointed to make an entomological evaluation of the tussock moth population.

Evaluation Objectives

1. Determine the location and size of the areas defoliated by the tussock moth during 1972.

2. Determine the degree of damage which had occurred to the defoliated trees within the 1972 infested area.

3. Determine which areas in the 1972 infestation had tussock moth populations with the potential for continuing defoliation in 1973.

4. Determine which areas outside the 1972 infestation contained egg masses capable of producing tussock moth populations which could do an unacceptable amount of defoliation in 1973.

5. Determine what the possibility was for natural factors such as parasites, disease, or weather to reduce the population sufficiently to prevent unacceptable damage in 1973.

Evaluation Procedures

1. The active areas of the tussock moth were first located and mapped during the annual aerial detection surveys. When the magnitude of the infestation was realized, additional flights were made in fixed-wing aircraft in the Blue Mountains and the Lake Roosevelt areas. The area surveyed was gridded by flight lines two miles apart and all defoliation believed to be caused by the tussock moth was sketched on half-inch USFS maps or USGS-15 minute quad maps. These flights were made during July and early August 1972.

2. The need for a more accurate map showing the degree of damage developed when the first attempt was made to evaluate the timber losses in the Blue Mountains area. During September an aerial survey of the timbered area from Pomeroy, Washington, south to La Grande, Oregon, was made by helicopter. With the helicopter time was taken to check out each drainage and small island of timber. The helicopter could move in close enough so that the observer could map all visible defoliation in one of the following classes:

   1 - Tree Killing - Fifty percent or more of the host trees within these areas have been completely defoliated and the remainder have heavy defoliation.

   2 - Top Killing - Fifty percent or more of the host trees have at least the top quarter of the crown completely defoliated.

   3 - Defoliated - The current year's foliage had been removed on most of the host trees but less than a quarter of the crown has been completely defoliated. This defoliation is visible from survey aircraft.

3. The tussock moth was also reported by foresters and loggers as being active in areas where damage was not visible during the helicopter survey. To determine the extent and location of these areas, survey scouts were directed to drive all roads adjacent to the units that had been mapped as moth-infested during the helicopter survey. At intervals of 1 mile the scout examined the foliage of host-type trees and recorded the presence or absence of the tussock moth, tussock moth damage, or egg masses.

4. After the helicopter survey and the ground scouting were completed, maps were prepared showing the areas where moth activity had been observed. Entomological evaluation crews were assigned to collect data from each 1-mile-square section within the areas mapped. Much of this area is roadless and it was not possible to examine all sections, but the crews hiked or were air lifted by helicopter into many places otherwise inaccessible. Working in this manner the evaluation crews collected data from over 2,300 sections during an 8-week period in October and November of 1972.

5. Procedures used by the evaluation crews consisted of five surveys with parts of some interlocking. These surveys and their objectives were:

   A. To determine the presence or absence of the tussock moth in a given land line survey section (approximately 640 acres), the crew kept a record of any tussock moth activity observed during their travels within the section. This record indicated the sighting of tussock moth larvae (dead or alive), pupae cases, adult moths, old or new egg masses, and the observation of defoliation caused by feeding.

   B. To determine the degree of defoliation that could be expected in 1973, a tussock moth egg density plot was established in each section. Using as a base the sequential sampling method devised by Mason[1/] for distinguishing innocuous moth populations from those having outbreak potential, counts were made of the number of new eggs per thousand square inches of branch area. On each plot one to eight host trees were sampled with two full branches cut from the mid-crown and two from the lower crown. New egg masses were counted and the foliage area measured. Using the sequential sampling table provided, the crew examined from one to eight trees until the egg population placed the plot in one of three classes:

      (1) Heavy or threatening population plots were those with new egg counts of 20 or more per thousand square inches of branch area. It has been previously determined that this egg population level would result in an unacceptable degree of defoliation in 1973.

      (2) Intermediate or light population plots were those where some new tussock moth eggs were found on one or more of the eight trees sampled, but averaged less than 20 per thousand square inches of branch area.

1/ Mason, Richard R. 1969, Sequential Sampling of Douglas-fir Tussock Moth Populations, USDA Forest Service Research Note, PNW-102, PNW Forest and Range Experiment Station, Portland, Oregon.

(3) Absent plots were those where no new egg masses were found on any of the four branches from each of the eight trees sampled.

C. To determine the trend of the population in a tussock moth outbreak, Evenden and Jost[2/] found that a quantitative comparison of the current and preceding year's egg masses was a good criterion of population changes This comparison is commonly referred to as an "old to new egg mass ratio survey." In each section where the egg density survey resulted in a heavy or threatening classification an old to new egg mass ratio survey was made.

All cocoons were collected from one branch of 10 to 20 host trees. A minimum of 10 trees were sampled, with a maximum of 20, if needed, to collect 100 or more cocoons. Trees were selected in a straight line radiating from the center of the egg density survey plot. Cocoons collected on each plot were placed in a plastic sack and labeled with the township, range and section of the collection point. Collections were then forwarded to the laboratory for examination.

The cocoons were examined under low magnifying ring lamps in the laboratory. Counts were made of dead cocoons, emerged male cocoons, those with old egg masses, and those with new egg masses. An old to new egg mass ratio was calculated for each plot and these ratios were printed on an infestation map so that an overall ratio could be viewed for each area or unit.

D. To determine if the nuclear polyhedrosis virus, which is considered the most important natural enemy of the tussock moth, is present in any outbreak areas and where and to what degree, new egg masses were collected. At each egg density plot where new egg masses were found, the first five egg masses counted were collected and placed in a paper bag. The bag was then sealed and the collection location recorded on it. These collections were then stored in insulated foam boxes to keep them from becoming overheated until they could be transported to the Insect Disease Research Work Unit at Corvallis, Oregon.

The eggs are being kept in cold storage (34^{o}) for a dormant period through January. Virus incidence and distribution will be determined by hatching the collected egg masses individually in petri dishes. The number

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2/ Evenden, James C. and E. J. Jost 1947, Tussock Moth Control, North Idaho, 1947, Forest Service, USDA, Missoula, Montana

of larvae dying of polyhedrosis in the first instar will be used to determine the virus incidence at each collection point. The number of egg masses producing virus-diseased larvae will be used as an additional factor in the determination of virus distribution in the current infestation. This virus incidence and distribution data will provide the next to last consideration in predicting the damage to be expected in 1973. Due to the long period of cold storage necessary to break dormancy, this data will not be available before mid-March. Therefore, any control plans or research tests planned for selected areas will need to be reevaluated when this virus data becomes available.

E. There is some indication that a decline in the size of egg masses in an area is an indication that the infestation may decline in that area. To determine if there is a variance in the size of egg masses in any unit or area, plans have been made to measure the size of egg masses as they are reared for virus determination. Since the egg masses are in cold storage until late January, the data on the egg mass size will not be available until March.

Evaluation Results

Aerial Appraisal Surveys. The appraisal surveys made from aircraft during the fall of 1972 located and mapped nearly 200,000 acres of visible Douglas-fir tussock moth defoliation. This defoliation occurred on five units with nearly 90 percent of this total located in the Blue Mountain infestation (Walla-Walla and La Grande Units). Table 1 gives the size and location of the defoliated units. This table also breaks the degree of defoliation down into the three classes.

Of the 196,810 acres mapped as defoliated to some degree, 15,660 acres, or 8 percent, had tree killing (Class I) while 64,870 acres and approximately one-third of the total defoliated area had top-killed trees (Class II). The majority of the tree killing occurred in the Blue Mountain infestation where over 10,000 acres of host-type timber was killed. The majority of this timber loss occurred on the Umatilla National Forest lands.

While the total acreage killed on the other units was small, by a size comparison, it should be noted that the area with the largest percentage of tree killing was the Colville Unit, with tree mortality on 36 percent of the total infested acreage. This unit consisted of many small infestation centers, in pockets of host-type timber, on the Colville Indian Reservation and private lands on the south side of Roosevelt Lake bordering the reservation. On the larger Okanogan Unit, over 40 percent of the area was either killed or top killed.

Table 1

ACRES OF DEFOLIATION BY OWNERSHIP
AND DAMAGE CLASS IN 1972 1/

Area	Acres of Defoliation by Damage Class Class I	Class II	Class III	Total
OREGON				
Blue Mountain Unit				
Umatilla N.F.	5,090	33,470	37,030	75,590
Wallowa-Whitman N.F.	90	1,310	3,950	5,350
State & Private	3,750	13,820	20,140	37,710
Subtotal	8,390	48,600	61,120	118,650
WASHINGTON				
Blue Mountain Unit				
Umatilla N.F.	1,740	10,810	38,050	50,600
State & Private	0	1,080	3,270	4,350
Subtotal	1,740	11,890	41,320	54,950
Blue Mountain Total	10,670	60,490	102,440	173,600
Wenatchee Unit				
Wenatchee N.F.	0	280	2,450	2,730
Private land	0	440	2,040	2,480
Subtotal	0	720	4,490	5,210
Okanogan Unit				
Okanogan N.F.	280	0	1,120	1,400
Private land	2,930	2,500	6,320	11,750
Subtotal	3,210	2,500	7,440	13,150
Colville Unit				
Colville I.R.	100	290	1,470	1,860
Private land	1,680	870	440	2,990
Subtotal	1,780	1,160	1,910	4,850
Grand Total	15,660	64,870	116,280	196,810

1/ Only areas where defoliation is visible from the air--does not include all areas where the insect has been found on the ground.

Scouting Surveys

Scouts, checking at intervals along roads in host timber type adjacent to known defoliated areas and in areas with past tussock moth outbreak histories, located and mapped several new and previously unknown areas of tussock moth activity. These new centers were mostly located in areas where the moth population was low and the defoliation so light that it was not visible from the aircraft.

New moth activity centers were found in the Halfway, Puffer Butte, and Billy Meadows Guard Station areas in the Blue Mountains and at Mare's Eggs Spring on the Winema National Forest in Klamath County, Oregon. The size of the moth activity area at Lake Wenatchee increased and two additional pockets of infested timber were located on the south shore of Lake Roosevelt in Washington.

No tussock moth activity was found in the former outbreak areas on the Malheur and Ochoco National Forests in Oregon or at the 1971 outbreak at Cashmere, Washington.

The locating of these additional tussock moth-infested centers by the scouts significantly increased the size of the area which needed to be examined in detail during the entomological evaluation of the outbreak.

Egg Density Surveys

During October and November of 1972, evaluation crews made examinations for tussock moth activity on 2,384 square miles of known and suspected areas of tussock moth activity. In a large percentage of the 2,384 land sections examined, little or no moth activity was recorded. Since tussock moth population density varies widely within a given outbreak area, these sections cannot be considered entirely tussock moth free. Conversely, the sections with plots showing moth activity may not be completely infested and the data obtained may not be applicable to the entire section. There were also many sections, within the known moth activity area, where, due to the lack of roads or nature of the terrain, no observations were made except from the air. Data from adjacent sections was used in evaluating these areas.

Egg density survey plots were established in 2,100 sections and new egg masses were collected on one-fourth of these plots. Using a sequential sampling system, 320, or 15 percent of the plots, contained enough new egg masses to place these plots in a heavy classification. Heavy was the class given to plots with new egg counts of 20 or more per thousand square inches of branch foliage area which would cause an unacceptable level of defoliation in 1973, unless other factors such as the virus reduced the level of the larval population to acceptable levels.

Distribution of egg density plots classed as "heavy," varied from unit to unit and within units. The effects of this distribution is reported on by units later in the "Discussion" section of this report.

Egg Mass Ratio Surveys

In each section where an egg density plot was classed as "heavy," a collection was made to determine the ratio of old tussock moth egg masses to new egg masses. All units surveyed, with the exception of the Klamath Unit, had at least one "heavy" egg density plot. Therefore, egg ratio counts were made in all units except Klamath.

Ratios varied from a high of 16 new to each old egg mass in the Blue Mountains area and Colville Units, to a low of 0.67 new to each old egg mass on the Okanogan Unit. Results and evaluations of these ratio counts are presented by individual units in the "Discussion" section of this report.

Egg Mass Size Surveys

A determination of any variation in the number of eggs in egg masses collected from the infestation will be made during February. Approxiamtely 2,250 new egg masses from 450 infested sections were collected and are presently in cold storage. As these egg masses are placed in rearing, a selected number will be measured and the number of eggs per mass counted. A comparison of the number of eggs per mass by areas or units will be made to see if any variation in the number of eggs per mass may indicate a trend on the moth population. It is expected that this data will be available during March 1973.

Virus Survey

To determine the incidence of virus within the tussock moth population, five new egg masses were collected from each of 450 survey plots in the outbreak areas. These egg masses have been moved to the Forestry Sciences Laboratory at Corvallis, Oregon, where they are presently in cold storage. Prior experience has indicated that virus incidence comparable to that occurring in the field will not be obtained in the laboratory unless these eggs are refrigerated through January. Two weeks will be required for the eggs to hatch after being brought to room temperature, and another two weeks will be required before virus-caused mortality is complere; therefore, it will be about March 15, 1973 before the virus incidence in the sampled population can be determined.

If the incidence of virus in any unit or area is determined to be 10 to 20 percent or greater (Thompson 1973[3/]), then plans

3/ Personal communication with Dr. C. G. Thompson, Insect Disease Research Work Unit, USFS, Corvallis, Oregon.

for chemical control in these areas will need to be reevaluated in light of the possible collapse of the moth population.

Parasitology

Parasites are one of several biological control factors which normally work to keep endemic moth populations from expanding and to reduce these populations after they reach outbreak proportions. Little research data has been published on the role of parasites and their influence on tussock moth control but many observations have been recorded of their variety and quantity during major outbreaks. The lack of tussock moths at other times has made the study of parasitic impact on endemic populations extremely difficult.

In an attempt to increase the effectiveness of parasites in controlling the tussock moth, one species of an imported parasite Calosoma sycophanta (L.) was released at Northport, Washington in 1930. Later two additional species Compsilura concinnata (Meig.) and Pimpla turionellae (L.) were released near Hailey, Idaho during 1939. Approximately 4,000 individuals were released; however, none have been recovered in subsequent collections conducted in these areas.

Several species of native insects have been credited as parasitizing tussock moths in Oregon and Washington. Among these, some of the most important are a sarcophagid fly Pseudosarcophaga affinis (Fall.), a tachinid fly, several species of wasps including Theronia fulvescens, Itoplectis viduata, I., 4-Cingulata and undetermined species of Phobocampe, Campoplex, Coccygominus and Ephialtes. During the current outbreak in certain areas on the eastern slope of Mount Emily, the pupae of Phobocampe were numerous during August of 1972.

The above species attack and parasitize the larval stages of the tussock moth. Some kill the larvae and emerge prior to pupation while others emerge later from the moth pupae. Any attempt to measure the role each of these parasites plays in reducing the current tussock moth population would be economically unjustified even if it was biologically possible. In the entomological evaluation of the current outbreak we are interested in the results of the collective action of this group of parasites.

To evaluate the impact of larval and pupal parasites on the current tussock moth population, surveys were made to determine the number of overwintering eggs in the outbreak area. Prior to the time these eggs were laid, the parasites had already reduced the population of the adult moths. Therefore, when the egg stage was evaluated, the action of parasites in reducing the population during 1972 was indirectly considered.

At the same time the eggs were counted, a survey was made of the number of pupae that had died from any cause. This mortality, as evidenced by emergence holes or remaining pupal cases, is primarily caused by parasites. During previous outbreaks in Oregon and Washington pupal mortality has ranged from 24 to 89 percent. There have also been reports of parasitism as high as 97 percent in residual moth populations following control of outbreaks in other areas. Pupal mortality recorded in the current outbreak area from collections made during the fall of 1972 were:

Lake Wenatchee Unit	85.3 percent
Godman Unit	68.8 percent
Mill Creek Unit	70.8 percent
Looking Glass Unit	57.7 percent
La Grande Unit	58.7 percent

The accumulated data on this high level of parasitism is of value when projecting the possible trend of moth populations beyond the 1973 larval period. Indications are that such a parasite population will have considerable effect in limiting the expansion of the moth population without any effort from other controlling factors. If other factors such as the virus or chemical control reduce the moth population during the summer of 1973, it appears that there will then be enough parasitic activity to wipe out the residual population prior to egg laying in the fall.

In addition to the action of parasites on the larvae and pupae, another important group of parasites are actively parasitizing the eggs. Probably the most important member of this group is a small wasp Trichogramma minuta Riley, which lays its eggs in the fall and the adults emerge in the spring about the same time the tussock moth eggs hatch. Close to 20 percent of the eggs have been parasitized by this species as shown by collections made during other outbreaks.

Another egg parasite often thought to be a major controlling factor in former outbreaks is a species of Telenomus. The only reference to the controlling action of this parasite on a tussock moth outbreak is from a field report on the 1929 infestation at Weiser, Idaho. Balch[4/] reported "This parasite was observed within the eggs of a tussock moth pupa which died before transforming. The eggs within the pupa were fully formed and half of them had been parasitized." This is apparently the source of the statement "Telenomus may destroy half of the eggs in an infested area" found published in literature.

4/ Balch, R. E. 1929, The Fir Tussock Moth (Observations in 1929) Forest Field Station, Coeur d'Alene, Idaho 25 pp. Unpublished.

At present, egg masses selected from throughout the current outbreak area are being hatched in an effort to measure the degree of egg parasitism. The numbers of tussock moth larvae that emerge, as well as the numbers and species of egg parasites appearing, will be recorded. Since some species of egg parasites produce many offspring from one host egg, the exact degree of parasitism cannot be computed, but reduction in the number of tussock moth larvae emerging can be determined. Should there be a significant reduction in the number of larvae emerging as a result of parasites or other factors, damage estimated will be reassessed.

Discussion

Blue Mountains Outbreak
(See maps one to six)

Covering a gross area of over one million acres, the Blue Mountains outbreak extends from Baker in northeastern Oregon northward to Pomeroy in southeastern Washington. This outbreak covers parts of Umatilla, Wallowa, Baker, and Union Counties in Oregon and Asotin, Garfield, Columbia, and Walla Walla Counties in Washington.

Through aerial insect damage detection surveys, 173,000 acres which suffered tussock moth defoliation during 1972, were located and mapped. Evaluation surveys during the fall of 1972 located many additional acres where moth populations overwintering in the egg stage, pose a threat in 1973. The total area of possible defoliation in 1973 contains a net acreage of slightly more than 400,000 acres, with three-fourths of this area in Oregon. These figures are as precise as possible at this time. Decreases could be expected as a result of refinement in areas covered by host timber, lack of control in buffer strips along major streams, or virus-caused reduction in moth populations. Increases could result from movement of the moths in early larval stages or from development of moth populations in place.

While all of this area is threatened by continued defoliation resulting from larval feeding, different degrees of hazard exist. Some of the factors determining the degree of hazard are: residual moth population, degree of pest defoliation, food availability, and reduction or possible reduction in the moth population due to natural control factors such as parasites and virus.

La Grande Unit consists of an area bounded in a triangle by Pendleton, Walla Walla, and La Grande. Mt. Emily, Elgin, Meacham, and the area south of Tollgate are included in this unit. Defoliation occurred over most of this area in 1972. There are also indications that defoliation by the moth occurred on a few small spots on the lower slopes of Mt. Emily in 1971.

There are large numbers of new egg masses present throughout this area in both the defoliated and green host-type timber stands. Egg density plots were classed as heavy on 92 sections and intermediate on an additional 40. Most of the plots located in defoliated areas and in adjacent stands were in the heavy class. Lighter or intermediate populations were recorded in more distant areas south of the freeway between Meacham and Hilgard. An average of the old-to-new egg mass ratios within the townships in the unit showed a 1:16 increase.

All of these data indicate that there will be a very large moth population available to defoliate this unit in June. A high density tussock moth population such as was present in this area in 1972 and is expected in 1973, is considered a major factor in the rate of spread of the virus within this population. Should the virus incidence in this area be significant, 10-15 percent or greater, the collapse of the moth population could be quite rapid. However, it is doubtful that it could stop the early killing of the new growth which may be vital to the survival of the trees partly defoliated in 1972.

Sled Springs Unit consists of the northern-most arm of the Wallowa-Whitman National Forest between Wallowa and Enterprise and north to the Washington State line.

No defoliation, with the exception of four small scattered areas of under 1,000 acres each, were observed within this unit in 1972. However, new egg masses were found on 48 of 193 egg density plots examined in this area during October and November. Twenty-nine of the egg counts on these plots were classed as heavy and 19 as intermediate, while additional evidence of tussock moth activity was recorded in another 91 sections. A valid old-to-new egg mass ratio could not be determined in this unit as most of the collections contained only new egg masses. This is believed to indicate a rapid buildup in a newly developing infestation.

Heavy defoliation over a large area within the forest boundary and west of State Highway number 3 is indicated for 1973. Defoliation is also expected to occur within a radius of 2 or 3 miles of Coyote Spring Campground where light defoliation was observed during the ground surveys. Seven egg density plots in this area were classified as "heavy."

Godman Unit is the rather large area between Pomeroy on the north and the Wenaha River just south of the Oregon State line.

Most of this area suffered some defoliation by the tussock moth during 1972. There were a few small patches of tree killing, but larval feeding resulted in only top killing or general defoliation over most of the unit.

Examinations on 205 egg density plots, located in and adjacent to the stands defoliated in 1972, showed a rather general spread around the northern-most areas but little spread to the east or west of the main body of defoliated timber. On the southern side, plots were few and scattered due to the inaccessibility of the area along the Wenaha River. Data from these plots indicated that the aerial survey had well defined the infested area.

Over the unit as a whole, 48 egg density plots were classed as heavy and 11 as intermediate. The remainder contained no new egg masses and were mainly located 2 to 10 miles east or west of the area mapped as defoliated. There appears to have been a rather high (66 percent) pupal mortality but, in spite of this, the old-to-new egg mass ratio was a high 1:24.

Expectations for 1973 are for continued heavy defoliation in the old infested area with some spread around the northern part of the unit. In the main or central area, spread is expected to be confined to stands of host-type intermingled with stands defoliated in 1972.

Mill Creek Unit consists of the Mill Creek Watershed Roadless Area south to State Highway 204 at Tollgate. Ten Forest Service recreation sites, including Jubilee Lake, are included within this unit.

During 1972, extremely heavy defoliation occurred in much of this unit, resulting in large areas of tree mortality and top killing. Spread of the moth to the west of the unit is limited by the lack of host-type timber. Survey coverage was not as thorough in this unit as in many other areas due to the roadless nature of the Mill Creek watershed. There were eleven egg density plots in the heavy class, mostly within the old defoliated area and the old-to-new egg ratio was 1:35, which is extremely high. Survey plots adjacent to the unit indicate that there had been little spread of the infestation to the host-type stands at lower elevations to the east.

A large larval population can be expected in this unit after the egg hatch but lack of food to keep this population growing could be beneficial as there will be little foliage available in many stands. Getting a rapid enough reduction in the moth population to prevent additional tree mortality could be a major control problem in this unit.

Clark Creek Unit consists of the four townships centered by the Clark Creek Guard Station located 10 miles north of Cove, Oregon.

Tussock moth activity has been reported in this area but no defoliation was observed during the aerial surveys. Ground evaluation surveys established 48 egg density plots in the

area and found no new egg masses. Evidence of the moth was only found in four scattered sections.

Little, if any, tussock moth activity is expected in this area in 1973.

Halfway Unit consists of Wallowa-Whitman National Forest lands on the Pine Ranger District from the town of Halfway north to the Imnaha River.

No visible defoliation was observed on this unit during annual aerial insect damage detection surveys in July. Later in the year several reports of defoliation were received from crews working on the ground in this area. During November, counts on 97 egg density plots showed two areas with enough egg masses to class six plots as heavy and 20 as intermediate. There were also many plots on which no evidence of tussock moth activity was recorded. The old-to-new egg mass ratio on the heavy class plots was 1:12.

It is difficult to predict what may occur on this unit due to the large number of intermediate class plots and the total lack of tussock moth activity on other plots. It is possible that several small pockets of defoliation could appear without a general infestation resulting. There is, however, the possibility that the two centers of moth activity could blossom into a large-scale outbreak. The largest of these centers is located 3 miles southeast of Cornucopia. The smaller centers are just west of the junction of Pine and Duck Creeks.

Ukiah Unit consists of a large area south of Interstate Highway 80 North between La Grande and Pendleton and extending west to Ukiah.

Aerial surveys did not record any defoliation in this area during 1972, but there had been some unverified reports of tussock moth activity in the area and it is a natural area into which the outbreak could spread or develop. Several hundred survey plots blanketed the area. Data from these plots recorded tussock moth activity on only ten and new egg masses were found in only one small area. These eggs were on a few trees in the parking area of the Trough Creek Campground located on the North Fork of the John Day River.

With the exception of this one campground, no moth activity is expected in the unit during 1973. Control with ground application apparatus might be considered to reduce the hazard and possibility of spread from the campground.

Catherine Creek Unit consists of the Catherine Creek drainage southward over Four Point Ridge into the upper Eagle Creek drainage and ends at the Lily White Guard Station.

Egg density survey plots were located in 120 sections but evidence of tussock moth activity was found in only 13. Most of the moth activity was centered in three sections, southeast of the Two Color Guard Station. Here one egg mass plot was classed as heavy.

Tussock moth defoliation is not expected to be a problem in this area during 1973; however, there may be some moth activity in a small area of one or two sections between the Two Color and Lily White Guard Stations.

Puffer Butte Unit is a small area of state and private lands located several miles northeast of the main outbreak areas. Fields Spring State Park is located within this unit.

First observed during the annual aerial insect damage detection surveys, defoliation of fir stands on the top of several buttes was confirmed by ground crews. New egg masses were found on four of eleven egg density plots in this area. Moth activity appears to be confined to stands at higher elevations but old-to-new egg ratios of 1:13 indicate the moth is still very active.

Unacceptable defoliation of the higher elevation stands in this unit is anticipated in 1973.

Looking Glass Unit is composed of a large block of private land in Oregon, extending several miles from both sides of the Grand Ronde River from Looking Glass to Troy.

Extremely heavy defoliation occurred over much of this unit during 1972 and resulted in large areas of top kill and tree killing. New egg masses were found on two-thirds of the 180 egg density plots in the unit and 75 of these plots were classed as heavy. Most of the plots on which no eggs were found were scattered along the eastern edge of the unit. The percent (56 percent) of pupal mortality was about average but appeared to have little effect on egg production as egg ratio counts were high throughout the unit, with the average ratio of one old to 33 new in the townships involved.

Large larval populations are expected in June and any defoliation to surviving trees at that time could be critical. Control must be applied immediately after egg hatch and before loss of the new growth occurs if additional tree mortality is to be prevented.

Northcentral Washington Outbreak

Scattered tussock moth infestations in northcentral Washington have been grouped in three units for evaluation purposes. All moth activity centers in Okanogan County are placed in the Okanogan Unit and may be located on the Okanogan County Map.

Those moth infestations in Lincoln and Stevens Counties are grouped in a unit with outbreak centers on the Colville Indian lands. These infestations are located on the Colville Indian Reservation Maps #1 and #2. The remaining infestations between Cashmere and Lake Wenatchee in Chelan County are included in the Wenatchee Unit and are located on the Wenatchee Map.

Okanogan Unit
(See Okanogan County Outbreak Map)

The Okanogan Unit consists of eight tussock moth activity centers totaling nearly 8,000 acres scattered over a large area in northcentral Washington within Okanogan County limits. Field tests with insecticides that showed promise for control of the tussock moth were made in June of 1972 in two of these centers. Data collected during these tests, together with data from the egg density and ratio surveys, were used to evaluate these areas.

An infested Douglas-fir stand of approximately 2,000 acres on Mt. Hull was heavily defoliated in 1971. Egg ratio surveys in the fall of 1971 revealed 20 new egg masses to each old. Virus surveys at that time showed a 0.4 percent virus incidence in the total sample. Defoliation was heavy during June and July of 1972 and a new area of defoliation with top killing developed to the east of the old area. During the late larval stage, some mortality was observed and collections examined by the Insect Disease Research Unit at Corvallis confirmed the presence of the virus. Egg density survey plots and population surveys on 160 trees in the insecticide test and check areas found no new egg masses in the fall of 1972. It appears that the tussock moth infestation in this area has collapsed from virus activity or as a joint result of insecticide testing and virus activity.

During June, heavy defoliation suddenly appeared in the fir stands on ridges 2 to 4 miles west of Oroville. This was an area where no tussock moth activity had been observed during two thorough aerial surveys in the fall of 1971. Ground surveys during October of 1972 found heavy egg concentrations in three sections. Host-type timber in this area is scattered and may limit the spread of the moth but defoliation can be expected in 1973 and tree mortality may result unless the virus, which is active in adjacent centers, reduces the moth population at an early larval stage. At present, there are no indications that this will occur.

Several thousand acres of Douglas-fir on the ridge east of Lake Wannacut were severely defoliated during 1972. Plans to field test insecticides in this area during late July were dropped when heavy mortality caused by virus occurred in late

larval stages. Only a few new egg masses were found on egg density plots in this area and the remainder of the moth population in this area is expected to collapse early in 1973.

There were two centers of moth activity northwest of Riverside in 1971 and two more developed uring the summer of 1972. Egg ratio surveys in one of the older centers in the fall of 1971 indicated 32 new egg masses for each old; therefore, this area was selected for field testing of Zectran. An adjacent infested area, where no egg surveys were made, was selected as a check area for the Zectran test area. Defoliation in the Zectran test area and a new area to the south was heavy but there was a considerable reduction in this population during the Zectran tests. Moth activity in the check area was low with little new defoliation. Some virus activity was observed in these areas during late July and egg density surveys in October found new eggs in only three sections. Egg ratio surveys in these sections found only two new masses for each three old. Moth population studies on 160 trees in the spray and check areas indicated no new egg masses. It is expected that there will be little defoliation in this area during 1973.

Colville Unit
(See Colville and Ferry County Infestation Maps)

The Colville Unit consists of approximately 20,000 acres of moth-infested timber in many small pockets scattered through Ferry, Lincoln, and Stevens Counties in northeast Washington. This acreage figure does not give a true picture of the timber value of the stands infested as the trees are acattered and many are small. The better timber stands involved are on areas infested in the Colville Indian Reservation with the largest active center northeast of the junction of the Sanpoil and Columbia Rivers. Much of the acreage on private lands is in small stands of a few acres each in the bottom of the draws on the south side of the Columbia River (Lake Roosevelt).

On the Colville Indian Reservation, egg density surveys and egg ratio surveys indicate that there could be considerable defoliation in 1973 in the area northeast of the Sanpoil-Columbia River junction which is the southeast quarter of township 29 north, range 33 east, and in the southwest quarter of township 29 north, range 34 east. Another area where moth damage can be expected is in the five sections north of the lookout in township 31 north and range 28 east where light defoliation occurred in 1972. Few new egg masses were found in other 1972 moth activity centers on reservation lands. Indications are that the moth population is on the decline in these areas but there is a possibility that, due to the nature of these scattered stands, new spot infestations may develop.

As host trees were defoliated, lack of food caused the moth population to collapse in some of the spot infestations located in the bottoms of draws south of the Columbia River. In some other areas, the moth population has taken a sudden drop, perhaps due to the virus. Surveys did locate an area of several thousand acres at the intersection of townships 27 and 28 north with ranges 32 and 33 east where egg density counts indicate there may be considerable defoliation in 1973. There had been moderate defoliation in this area in 1972 and additional defoliation of any degree could be a problem. Another area northwest of this outbreak is still quite active but with the moth population at a lower level; however, it is difficult to determine if the population is increasing or decreasing. Pupal parasite activity in these areas south of the river was also quite low.

Wenatchee Unit
(See Wenatchee Outbreak Map)

This unit consists of about 7,000 acres contained in several small centers of tussock moth activity between Cashmere and the south end of Lake Wenatchee. The infested areas are a mixture of private and Wenatchee National Forest lands all in Chelan County, Washington. Tussock moth activity was first recorded in the unit during 1971 when 1,600 acres of Douglas-fir trees were defoliated on the slopes above the orchards to the southwest of Cashmere. This outbreak was terminated in July of 1971, apparently through the use of DDT and/or lindane by unknown applicators treating adjacent fruit orchards. Salvage logging during the summer of 1972 removed most of the fir from the hillside and egg density surveys made among the few remaining trees found no new egg masses. It appears that the outbreak has collapsed in the Cashmere area of this unit.

Surveys were made in the Hansel Creek, Deer Park Springs, and Rock Island Campground areas where suspected tussock moth defoliation had been mapped during the aerial surveys. It was found that, although there was some tussock moth activity, most of the defoliation was caused by the spruce budworm. No new tussock moth egg masses were found on egg density plots. Indications are that there will be little, if any, tussock moth activity in these areas during 1973.

Defoliation in the Chewaukum Creek Campground area was found to be the result of both tussock moth and spruce budworm feeding. Heavy tussock moth egg population counts were found on only one of five egg density plots in the area, but evidence of the presence of heavy spruce budworm populations was reported. It is possible that the joint defoliation of both insects in this area may cause pockets of heavy defoliation.

Surveys in the Johnney Creek Campground area turned up evidence of tussock moth and spruce budworm feeding in the spring of 1972. During the egg density surveys no new eggs or any indication of current tussock moth activity were seen.

Heavy tussock moth defoliation was first reported at the south end of Lake Wenatchee in June of 1972. This is the most westerly outbreak of the tussock moth ever recorded in Washinton, although individual trees have been defoliated as far west as Olympia. Egg density surveys indicate that there will be a heavy larval population present on approximately 5,000 acres in this area in 1973. New to old egg ratio surveys indicate a 2.5 fold increase in early larval populations. This is considered a rather low increase and it will be interesting to see what the virus incidence is in this area. It is believed that there will be considerable defoliation early in 1973 if the virus incidence is low.

Klamath Area

A very light population of the tussock moth has been active during the last two years in a small area northwest of Agency Lake on the edge of the Winema National Forest. While not considered an outbreak, the area where the moth is active is located along Forest Service Road Number 323 for 3 miles north and south of Mares Egg Spring.

During the summer of 1972, larvae were collected at 21 beating plots along this road. After much searching during September, new egg masses were found in four locations. Only two egg masses were found on the eight egg density survey plots examined during November 1972.

This may be a moth population that for some unknown reason or reasons has been unable to develop to outbreak proportions, or it may be a population that is just starting to develop. While at the present time it cannot be considered to be threatening, it will bear close watching in the future.

Recommendations

Douglas-fir tussock moth outbreaks usually explode on the landscape without warning and decline as abruptly. During the short period the outbreak lasts, the feeding larvae manage to devastate the infested timber stands. An important function in the evaluation of such an outbreak is determining if the infestation has passed its peak and the abrupt decline is about to commence. Of equal importance is the evaluation of what may occur to the partly defoliated trees if additional feeding occurs before complete collapse of the moth population. Therefore, in all considerations when recommending for or against control, the condition of the trees may be as important as the trend of the tussock moth population.

Evidence of tussock moth feeding as early as 1970 at Cashmere, Washington and defoliation of Douglas-fir stands at Oroville, Riverside, Lake Chelan as well as Cashmere during 1971 would indicate that the northcentral Washington outbreak is a year older than the outbreak in the Blue Mountains. During 1972, virus-caused tussock moth mortality was recorded on three activity centers in Okanogan County. Evaluation surveys also recorded the collapse, from unknown reasons, of moth populations at several centers on the Colville Unit.

While these are all good indications that the outbreak in north-central Washington may have started to decline, evaluation surveys located several areas where egg density counts and old-to-new egg ratios forecast heavy defoliation during 1973 and control is recommended before this occurs.

These areas are:

Okanogan Unit

1. Infested stands on the ridges 2 to 3 miles west of Oroville.

2. Turtle Lake area, 10 miles north of Riverside.

3. Hunsinger Lake area, 5 miles northwest of Omak.

Colville Unit

1. The lightly defoliated area just north of the lookout in section 24, township 31 north, range 28 east.

2. The large area defoliated in 1972 northeast of the junction of the Sanpoil and Columbia River.

3. In the timbered draws south of the Columbia River at the intersection of townships 27 and 28 north with ranges 32 and 33 east.

4. Sections 19, 20, 28, 29 and 30 of township 28 north, range 32 east on south side of Columbia River.

Wenatchee Unit

1. Area of approximately 5,000 acres on the southeast end of Lake Wenatchee.

2. Small area of tussock moth and spruce budworm infestation at the Chewaukum Campground.

During 1972, there were several centers of heavy defoliation in the Lake Wenatchee area. Partial defoliation occurred on many trees in this high-use recreational area. Early control of the larval population will be required to prevent further tree mortality.

In the Blue Mountains, survey data indicates an increase in tussock moth populations in the area which suffered defoliation during 1972. Large tussock moth populations are also expected in adjacent stands of host-type timber as well as on new or newly discovered activity centers to the east and south of the 1972 infested area.

The areas where control is recommended for 1973 are divided into two groups. The first group (I) contains those units or areas where further tree mortality can only be prevented by the reduction of the larval population immediately after or during the egg hatch. This would need to occur before the first instar larvae have a chance to destroy the new foliage on the trees that were heavily defoliated during 1972. The second group (II) are those areas where the evaluation surveys indicate a large tussock moth population in 1973 but where only light if any defoliation occurred during 1972.

The objective of control in these areas should be aimed at a maximum reduction in the moth population. This could be accomplished by spraying at a later date after the egg hatch has been completed, possibly in the second and third instar.

Group I

1. La Grande Unit with the exception of the westerly most area where little defoliation occurred during 1972.
2. Mill Creek Unit.
3. Looking Glass Unit.
4. Sled Springs Unit west of Highway Number 3.
5. Godman Unit with the exception of the northern quarter.

Group II

1. Westerly most area of La Grande Unit.
2. Coyote Spring area of Sled Spring Unit.
3. Northern quarter of the Godman Unit.
4. Halfway Unit.
5. Trough Creek Campground on John Day River.
6. Puffer Butte Unit.

ENTOMOLOGICAL RE-EVALUATION

This section contains a further study of areas recommended for control in the original evaluation that was made prior to the preparation of the draft environmental statement. This re-evaluation reflects an analysis of data from the natural virus incidence survey that became available during March 1973.

When the original entomological evaluation of the tussock moth outbreak in Oregon and Washington was prepared, it was concluded that areas recommended for control would have to be evaluated again when results were available from the virus incidence survey.

Virus Incidence Determination

During the course of the tussock moth infested area surveys in the fall of 1972, five new egg masses were collected from each of approximately 440 survey plots. These eggs were placed in storage at the Forestry Sciences Laboratory, U. S. Forest Service at Corvallis, Oregon, and were refrigerated through January, as prior experience indicated that an extended cold storage period was required to ensure a good hatch.

Under the direction of Project Leader, Dr. C. G. Thompson, a section of each egg mass was removed in early February and hatched. The emerging larvae were reared for a 14-day period. At this time all dead larvae were examined to determine which of these had died from virus.

A total of 50,846 tussock moth larvae were hatched from 1,878 egg masses and of these 49,799 were still living after 14 days. A total of 1,047 dead larvae were examined of which 104 larvae from 40 egg masses were found to have died from a nuclear polyhedrosis virus.

Examination of these figures shows that two-tenths of one percent of the larvae reared died from virus. This percentage ranged slightly higher in some of the more heavily defoliated areas and somewhat less in the lightly defoliated areas. The virus killed larvae hatched from 2.1 percent of the total egg masses collected.

While the overall virus incidence for the outbreak was disappointingly low, the rate in some individual units proposed for chemical control was high enough to permit a re-evaluation of projected damage in light of a possible collapse of the moth population.

These units and their virus incidence rates are discussed in the following section under the individual units involved and the locations of those sections where virus was found during the survey are given in Table 1.

Re-evaluation Procedure

Upon determining the amount and distribution of virus within the outbreak area, a re-evaluation was undertaken of each unit where control had been originally recommended for 1973. Special attention was paid to units where tussock moth populations had been present for three years and also to those areas where little defoliation had occurred during 1972. These were mainly the units listed under Group II in the original evaluation report.

Many factors were examined and weighed before a decision was reached as to the areas which have to be included in the proposed chemical control project. Some of the factors used in reaching this decision were:

A. Survey intensity in the unit.
B. Density of new eggs in the unit. (See Table 2)
C. Ratio of new to old egg masses.
D. Host type present.
E. Degree of current defoliation.
F. Pupal mortality (parasite activity).
G. Egg hatch data.
H. Virus incidence in egg masses.
I. Virus determination in 1972 larval populations.
J. Survey results in adjacent units.

The weight given to a factor varied between units depending on other considerations. For instance, more weight would be placed on the virus incidence in units where the outbreak is entering its fourth year.

The re-evaluation led to the conclusion that several units originally recommended for control to prevent defoliation in 1973 could be deleted with only a minimal risk to trees in these units. The units removed from the list of areas proposed for control during 1973 (Appendix A, pages 35-37) are:

1. Halfway Unit
2. Puffer Butte Unit
3. Okanogan Unit
4. Colville Unit

Certain areas in the Godman, La Grande, and Looking Glass Units were reduced in size.

Removal of these units from the area where defoliation damage was projected during 1973 reduced the number of acres needing treatment from 434,000 acres to 281,000 acres. It is expected that if a DDT control project were undertaken, the area actually treated would be approximately 261,500 acres in the Blue Mountains and 5,000 acres in the Wenatchee Unit after the exclusion of such areas as buffer strips along major streams, open meadows, rock slides,

and stands of non-host timber, etc. The balance of the seriously affected areas will be used for the Zectran field test and other insecticide and biological agent experiments.

Re-evaluation of Halfway Unit

When the original evaluation of this unit was made, it was concluded that it would be difficult to predict what would occur due to the large number of intermediate egg class plots and the total lack of tussock moth activity on other plots. Since then results of the virus incidence survey indicate that the virus is active at a low level (0.5 percent virus incidence) in both outbreak centers on this unit.

Considering all the survey data available for this unit but giving heavy weight to the virus incidence and the lack of serious defoliation during 1972, it was concluded that the probability of significant tree damage occurring was rather low. Visible defoliation is still expected to occur during 1973, but the resulting damage is not expected to be serious. Therefore, this unit was removed from the list of units proposed for control.

Re-evaluation of Puffer Butte Unit

When the original evaluation of this unit was made, it was observed that new egg masses were found on four of eleven egg density plots. This infestation was confined to stands at higher elevations. A review of the data and maps of this unit indicate that the area infested is smaller than previously estimated. Three of the plots with new eggs were in close proximity. Virus was present in a very small degree in the area but not at sufficient levels to give expectations for a rapid decline. Since the virus is present, the area threatened small, and current defoliation light, this unit was removed from areas recommended for control.

An aerial survey should be made of this area in late June to see if any serious defoliation is occurring. If the defoliation is heavy and timber or other values warrant it, equipment could be diverted from the main project to treat the area in time to prevent serious damage.

Re-evaluation Okanogan Unit

The original evaluation of this area concluded that control might be necessary on three of eight infestation centers scattered over this large unit. During the re-evaluation heavy weight was placed on the fact that the virus was present in mature larvae late in July of 1972 at three centers. Surveys were also unable to find new egg masses at one other center, indicating a complete population collapse. The virus survey of the overwintering egg masses showed a virus incidence rate of 1.3 percent for the entire unit and 2.25 percent for the northern section of the unit where control had been recommended.

In light of the virus activity, both past and present, this unit was dropped from the areas needing chemical control during 1973.

Re-evaluation of Colville Unit

There are four small centers of tussock moth infestation in this unit that were originally recommended for inclusion in any control plans. The results of the virus incidence survey indicate that the virus is active at the two centers on Reservation lands located at Whitmore Lookout and in the Hellgate Canyon area. No virus was detected in the two centers south of the Columbia River. Both of these centers consist of many small pockets of scattered host trees, and it is difficult to predict exactly the pockets where heavy defoliation may occur.

This unit was dropped from the areas needing control but aerial observations will be made during June to locate any pockets of defoliation that may develop. Then, if serious defoliation does occur and timber resources warrant it, equipment and insecticide could be diverted from the Lake Wenatchee Unit in order to treat these small patches before serious loss occurs.

Re-evaluation of Godman Unit

This large unit, which includes most of the Blue Mountains' tussock moth outbreak north of the Wenaha River, had only one plot on which virus was found. Indications are that serious defoliation will occur over most of this unit in 1973. However, this review brought to light the fact that little survey data was available for a large area south of Diamond Peak. This is a rugged, roadless area and survey data was difficult to obtain. What little data was obtained showed five absent and two heavy egg density plots. The aerial survey map indicates that defoliation of all classes occurred over most of the host type in this area during September of 1972.

Partly due to the data from the egg density survey and partly due to the large size of the area being judged from such scant survey data, this area was dropped from the Godman Unit. It will be kept under aerial observation during June and if serious defoliation should start to occur then control might be considered.

Re-evaluation of La Grande Unit

The virus was found on only four of 123 plots sampled in this unit. These four plots were scattered but it is interesting to note that one was located in the area where heavy defoliation was observed but not reported by property owners during 1971. While the virus incidence is expected to increase throughout the summer, it is expected that the resulting drop in the larval population will not occur until shortly before pupation.

One isolated area of this unit of approximately 4,000 acres in size,

located in the vicinity of Tollgate, is actually a small center of heavy infestation surrounded by a larger area of a much lesser intensity. This area was removed from the La Grande Unit and reserved for the operational test of Zectran.

Re-evaluation of Looking Glass Unit

On the western edge of this unit is an isolated island of timber near Lookout Mountain where results of the virus incidence survey recorded virus on two of eight plots. The incidence rate was nearly two percent of all larvae reared from this area and was the highest recorded for any segregated area in the outbreak. Therefore, this area was removed from the Looking Glass Unit. It will be kept under observation in the expectation that the virus might develop fast enough to reduce the moth population before serious defoliation occurs. If this does not occur it can be added to the control unit in time to prevent serious damage.

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Table 1

Only 23 of 420 sections sampled had any virus incidence. Listed below is the location of these 23 collection points, number of eggs selected and hatched from each collection, and number of larvae reared for fourteen days which died of virus.

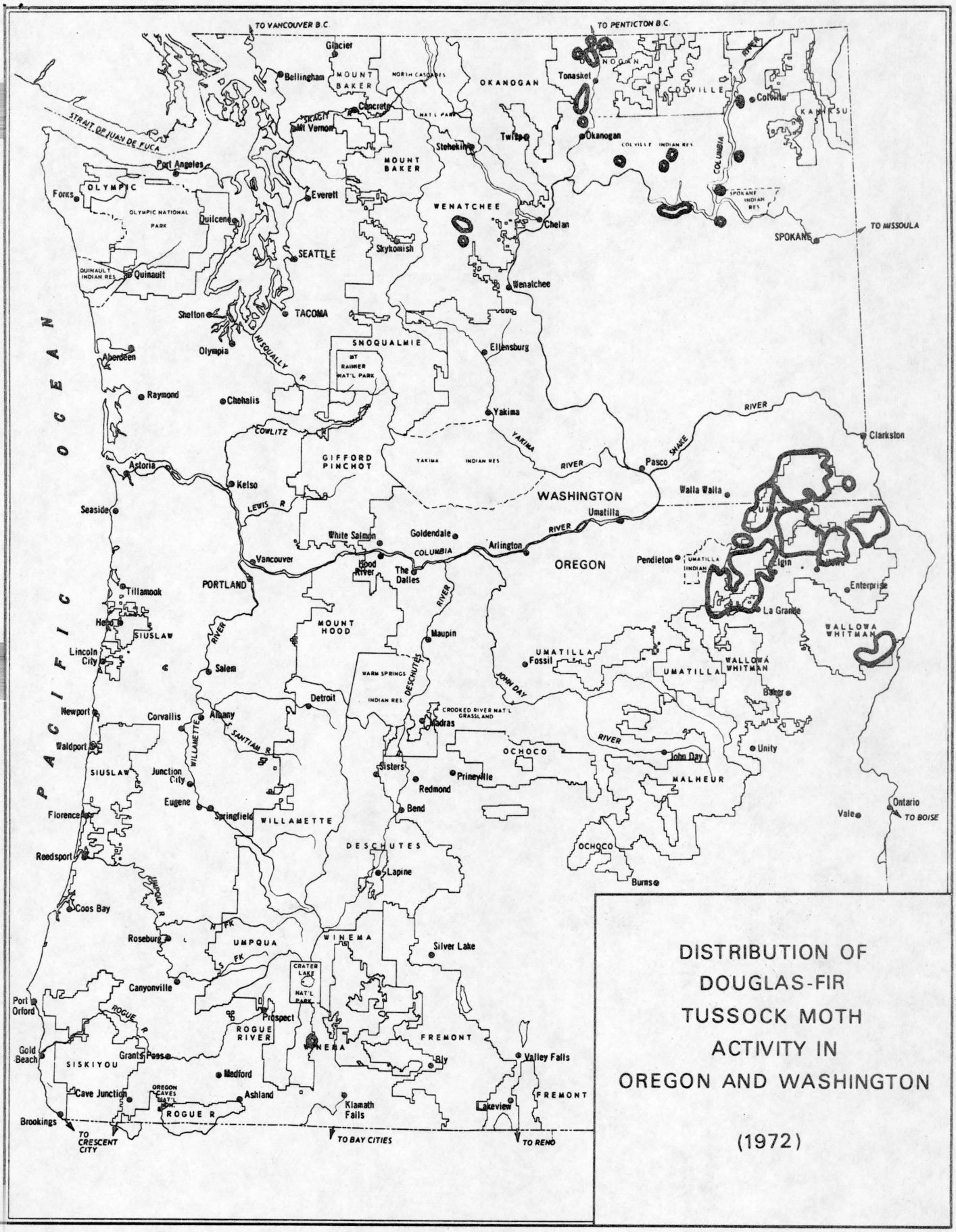
Area	Township	Range	Section	Reared	Died w/virus
N. Central Washington	40N	26E	25	54	3
" "	39N	27E	7	30	6
" "	31N	29E	18	76	3
" "	31N	28E	13	91	1
" "	29N	34E	29	73	1
S. East Washington	8N	40E	35	114	8
" "	7N	45E	5	142	1
N. East Oregon	5N	38E	2	88	5
" "	5N	38E	4	143	6
" "	5N	41E	1	193	3
" "	5N	41E	4	109	7
" "	4N	40E	11	154	15
" "	4N	40E	15	156	6
" "	4N	41E	24	52	1
" "	3N	42E	4	161	1
" "	3N	42E	7	170	1
" "	3N	43E	27	127	1
" "	2N	37E	1	173	1
" "	2N	38E	22	90	6
" "	2N	39E	7	81	5
" "	2S	38E	17	92	10
" "	6S	45E	34	149	10
" "	6S	47E	10	98	3

Table 2

General location and results of counts of overwintering Douglas-fir tussock moth eggs on sequential sampling plots.

Area	Heavy 1/	Intermediate	Absent
Units proposed for control			
Godman	43	4	18
Looking Glass	72	30	17
La Grande	101	18	9
Mill Creek	9	0	3
Wenatchee	9	1	0
Units reserved for tests			
Sled Springs	19	7	5
Tollgate	1	2	4
Other areas surveyed			
Blue Mountains	35	99	961
Pilot Rock - Ukiah	1	0	467
Klamath	0	1	4
N. Central Washington	28	17	108
Total	318	179	1,596

1/ Class limits and terminology use were from work forms provided by R. R. Mason for use in field surveys September 1972.

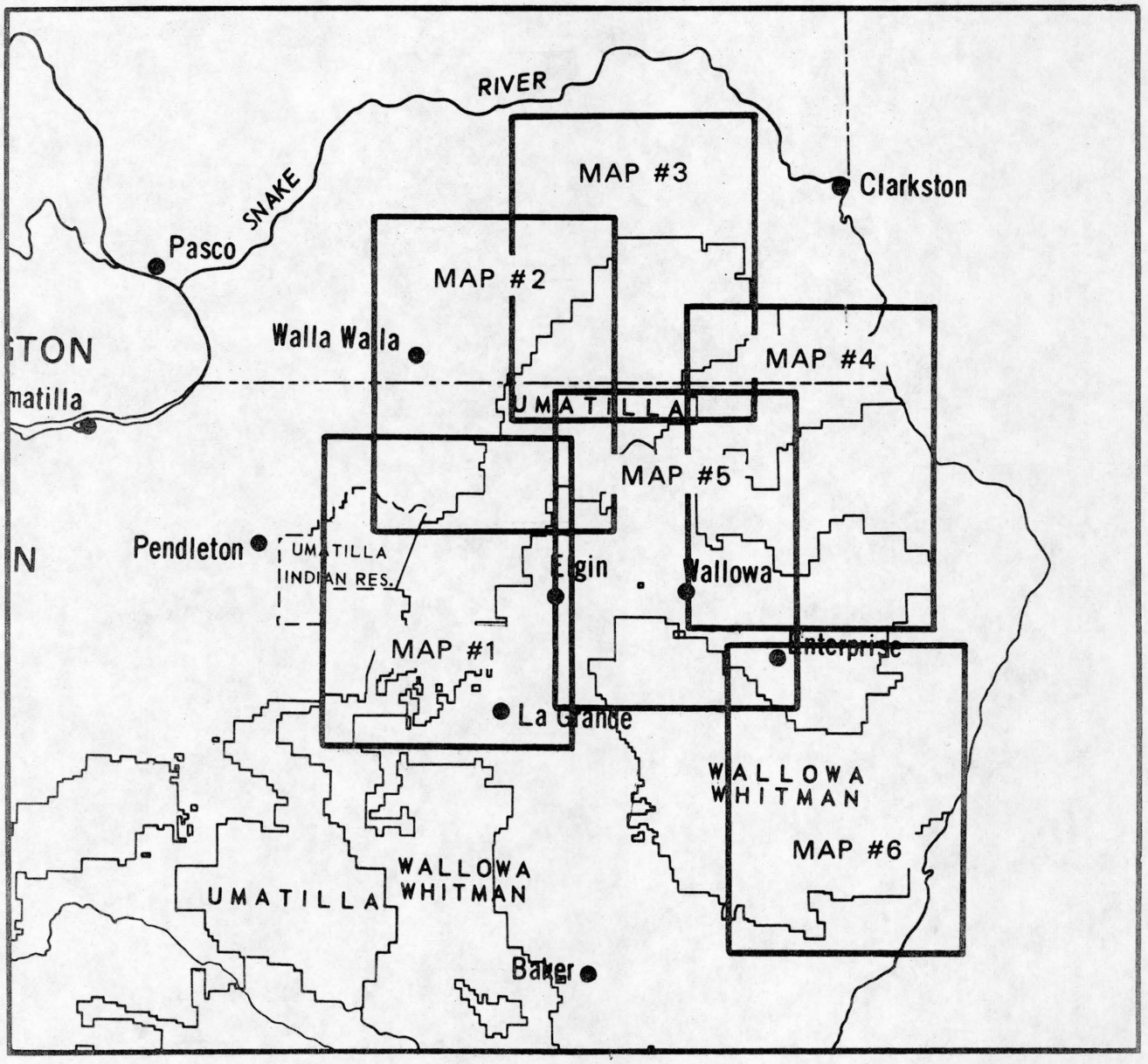


DISTRIBUTION OF DOUGLAS-FIR TUSSOCK MOTH ACTIVITY IN OREGON AND WASHINGTON

(1972)

VICINITY MAP

DOUGLAS-FIR TUSSOCK MOTH OUTBREAK IN THE BLUE MOUNTAIN AREA OF OREGON AND WASHINGTON



LEGEND
DOUGLAS-FIR TUSSOCK MOTH
BLUE MOUNTAIN OUTBREAK MAP #1
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
UMATILLA NATIONAL FOREST
BLUE MOUNTAIN
GRAVES BUTTE
BLACK MOUNTAIN
HUCKLEBERRY MOUNTAIN
MAHOGANY MOUNTAIN
SPRING MTN
SUGAR LOAF MTN
Grange Hall
INDIAN TRAIL CANYON
GRANDE RONDE VALLEY
GRANDE RONDE
La Grande
Island City
Flat Lake Guard Station
Radio tower
R35E
R36E
R37E
T1S
T2S

LEGEND

DOUGLAS-FIR TUSSOCK MOTH

BLUE MOUNTAIN OUTBREAK MAP #2

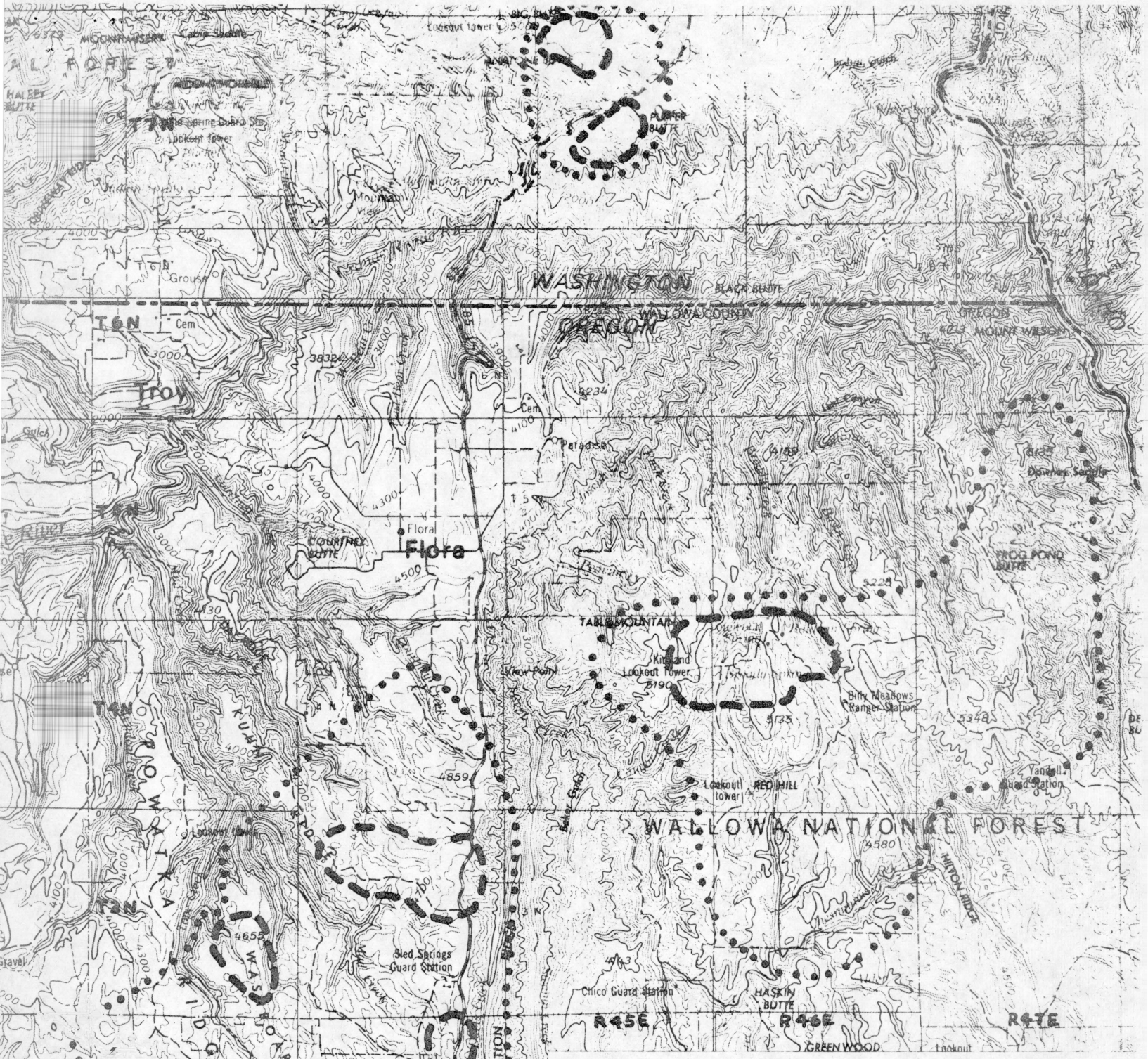
AREA OF TUSSOCK MOTH ACTIVITY (1972) .....

PROPOSED CONTROL AREA (1973) ———

PROPOSED INSECTICIDE TEST AREAS (1973) — — — —

Scale 1 in. = 4 miles

LEGEND
DOUGLAS-FIR TUSSOCK MOTH
BLUE MOUNTAIN OUTBREAK MAP #3
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
Pomeroy
Racetrack
Ferrell
Pataha City
Pataha Flat
Ruble Ranch
KNOTGRASS RIDGE
GOAT MOUNTAIN
GARFIELD CO
COLUMBIA CO
Rose Springs
Rose Springs Guard Sta.
Mountain Home Camp
Clearwater Ranger Station
DIAMOND PEAK
Lookout tower
MOUNTAIRSERK
OREGON BUTTE
Lookout House
Guard Station
Teacher Corral Station
BATTLE BUTTE
HALSEY BUTTE
DEADMAN PEAK
TABLE ROCK
TWIN BUTTE
WEASKUS CAMP
Long Meadows
Lookout tower
Cem
Grouse
Prairie Burnt Station
Lower Camp
Burnt Flat
Lookout house
Dumas
Mitway
Diamond
Lower Cabin
Cabin Saddle
Mount Horrible
Saddle Mountain Guard Sta.
Adjacent fire
Wenatchee
Grain Elev
Union Pacific
Baileysburg
Hoodyke Hollow
Rodgers Road
Cahill Mountain
Eckler
Lougar Canyon
Lougar Creek
Pataha Creek
Sweeney Gulch
Ben Dell Gulch
Dessert Gulch
Rickman Gulch
Pebble Ridge
Ridge
Robinette Mountain
Mulberry Mountain
Williams Ridge
Columbia County
Walla Walla County
Columbia Co
Garfield Co
Lower C
Oregon
Washington
T 12 N
T 11 N
T 10 N
T 9 N
T 8 N
T 7 N
T 6 N
R 39 E
R 40 E
R 41 E
R 42 E
R 43 E
2500
2596
2700
2954
3407
3832
4670
4803
5680
6579
2230
4401
4430
3000
4000



LEGEND

DOUGLAS-FIR TUSSOCK MOTH

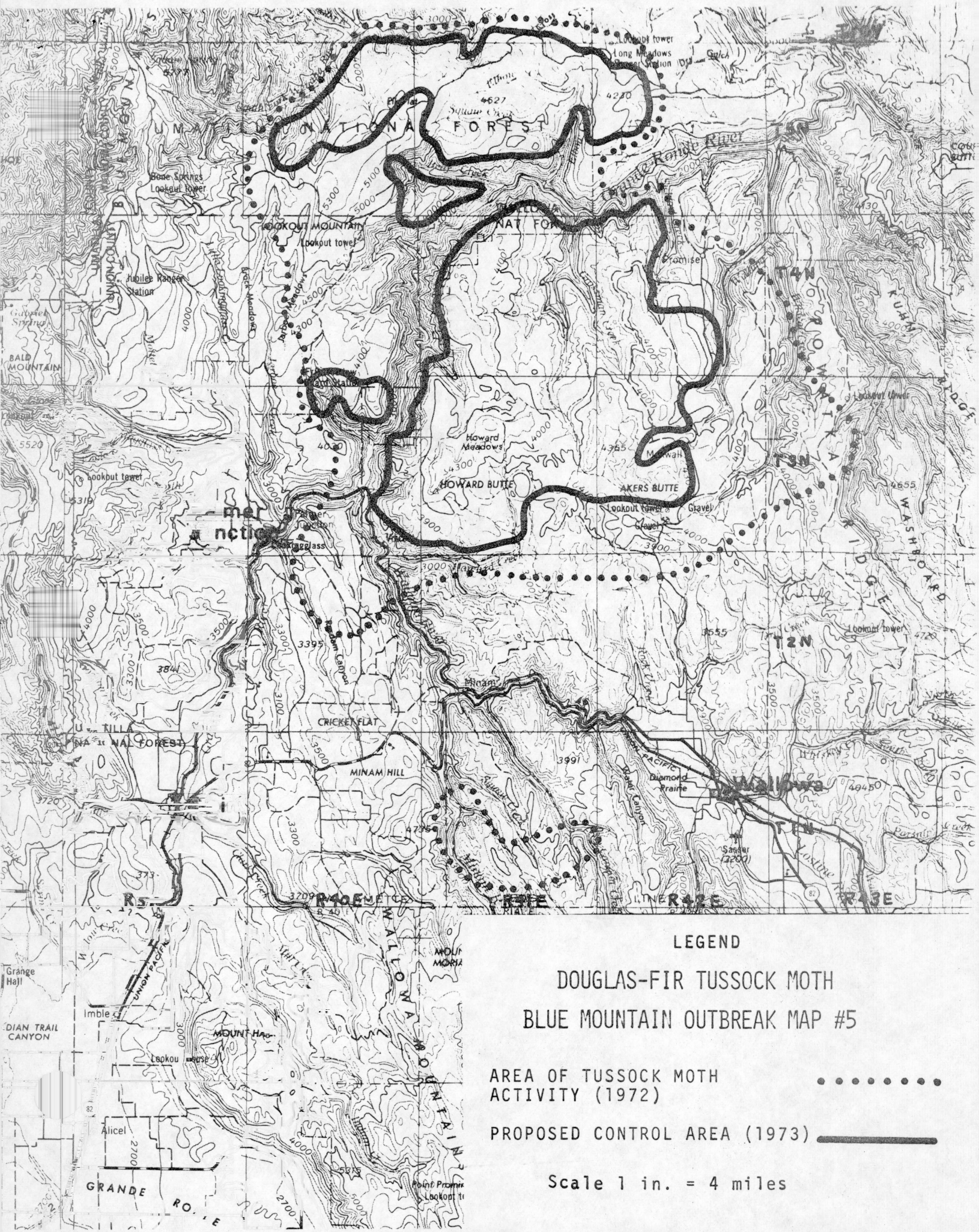
BLUE MOUNTAIN OUTBREAK MAP #4

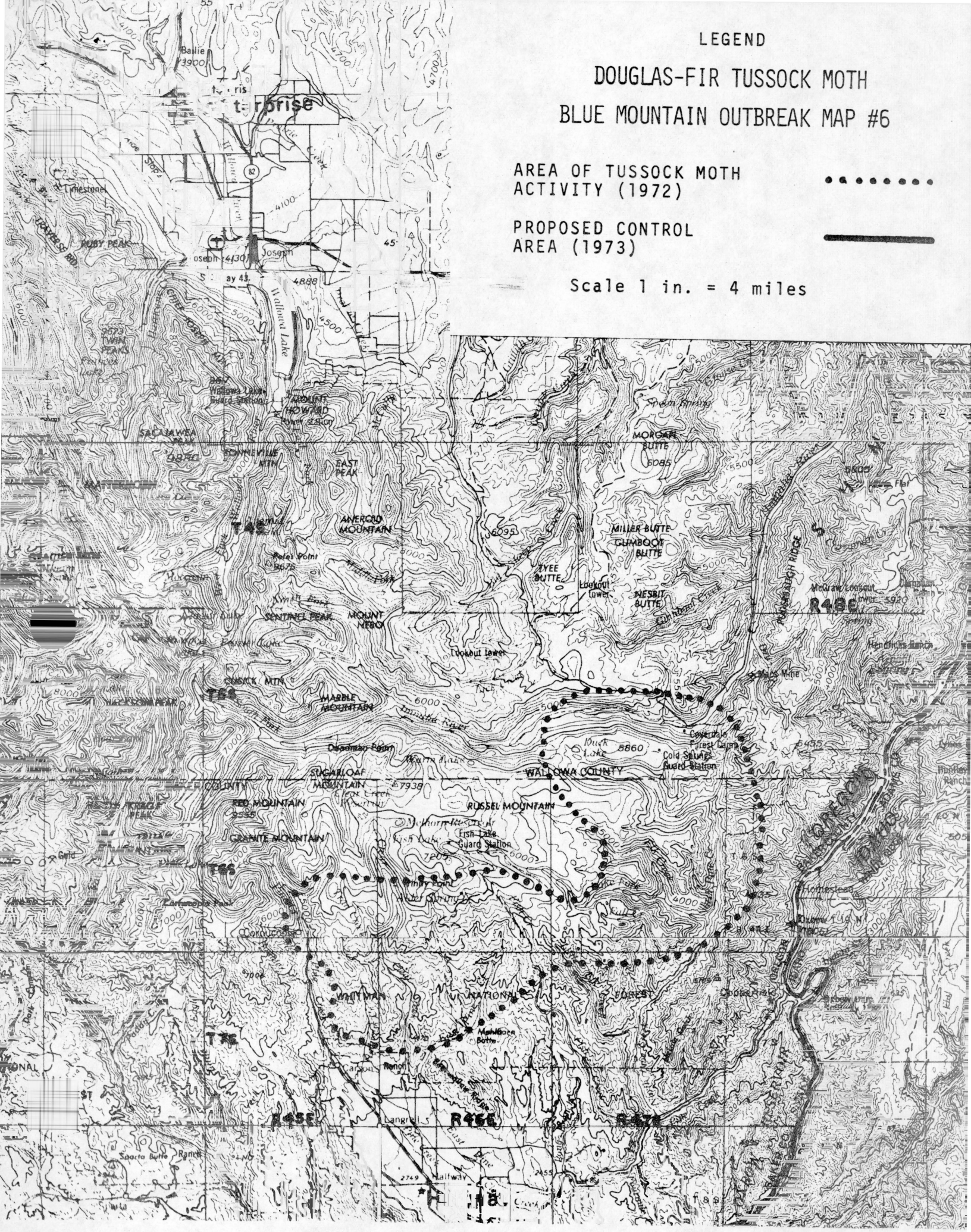
AREA OF TUSSOCK MOTH ACTIVITY (1972) .....

PROPOSED CONTROL AREA (1973) ———

PROPOSED INSECTICIDE TEST AREA (1973) — — —

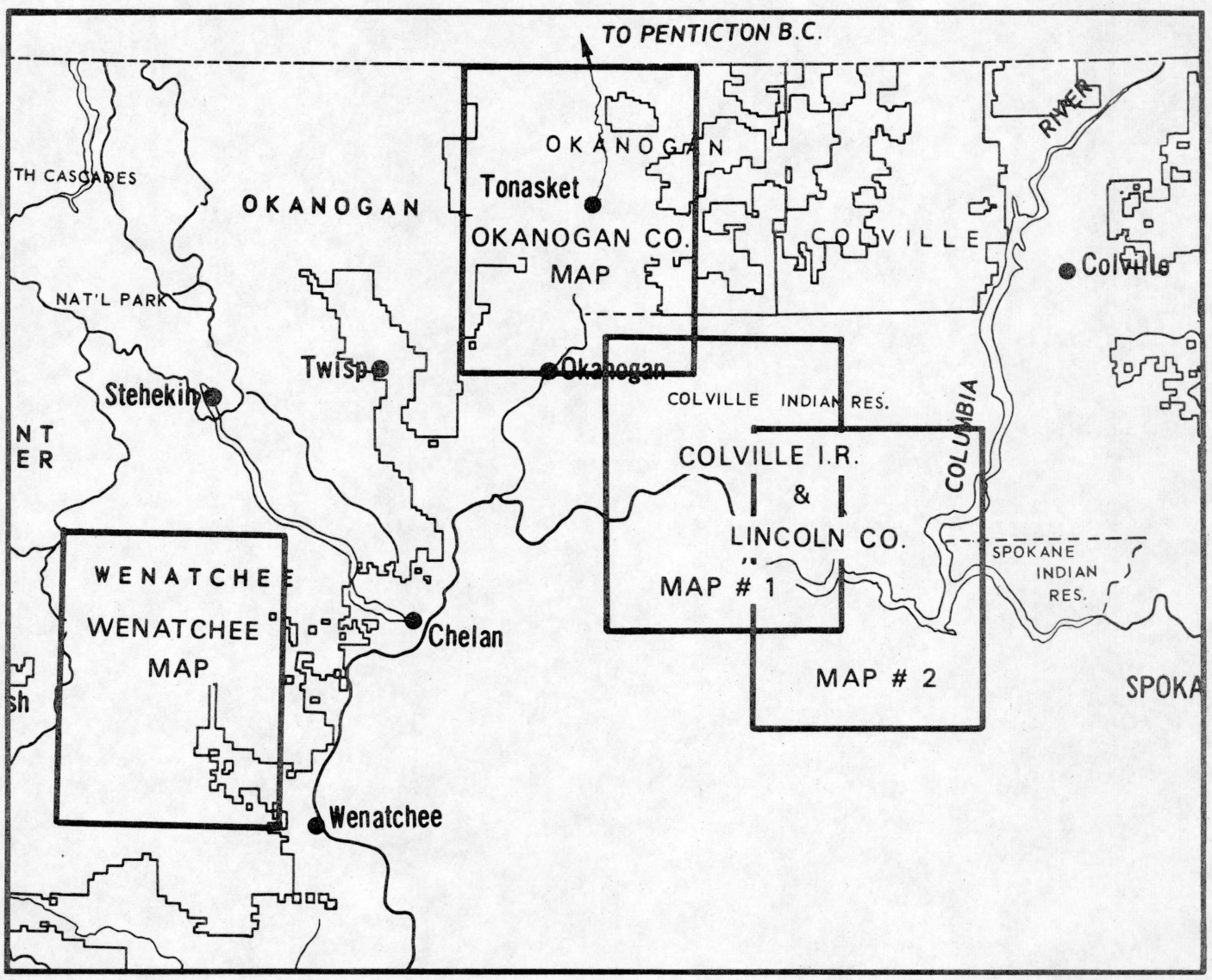
Scale 1 in. = 4 miles

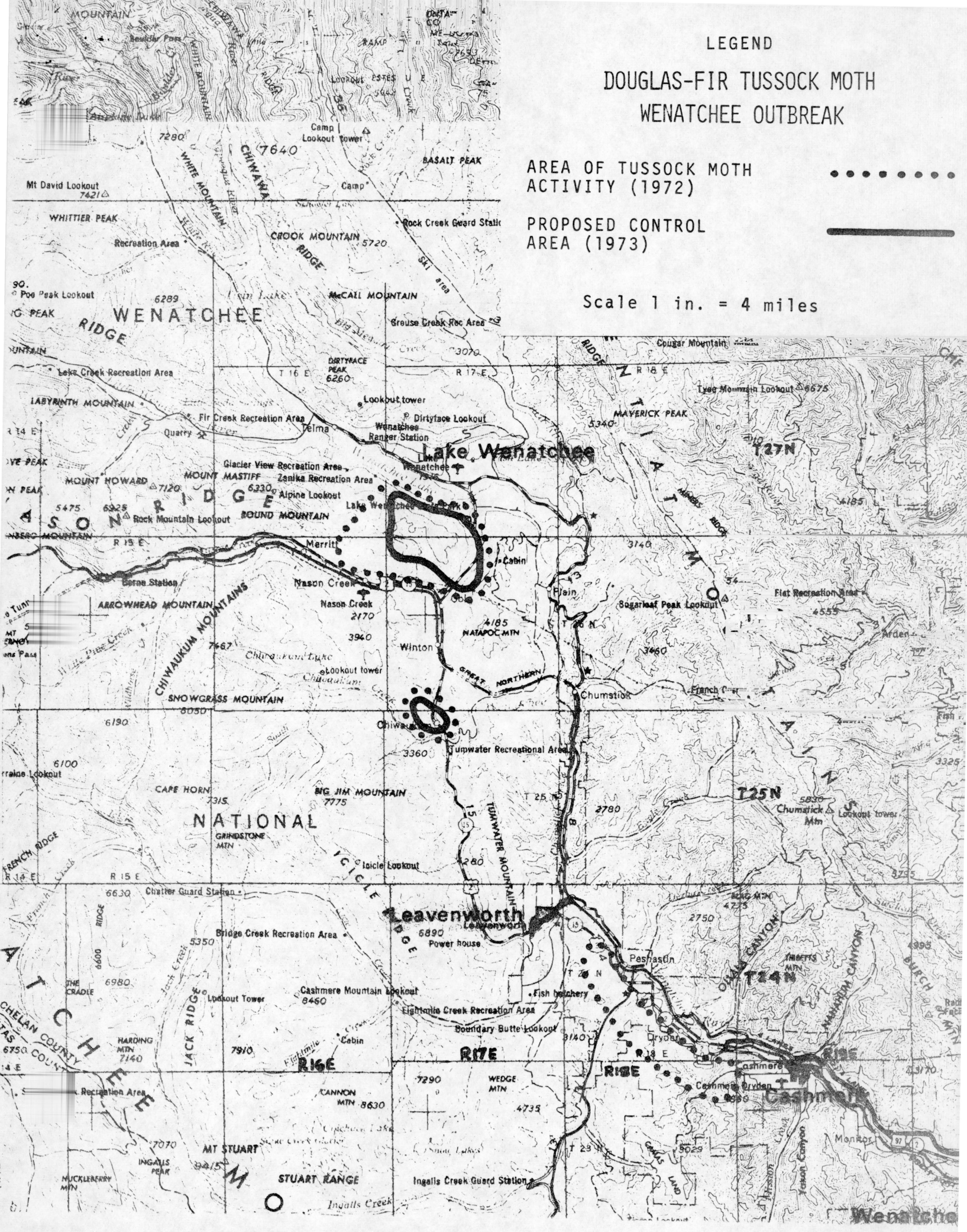

LOOKOUT MOUNTAIN
Lookout tower
Howard Meadows
HOWARD BUTTE
AKERS BUTTE
Lookout tower
Gravel
Bald Mountain Ranger Station
Boone Springs Lookout tower
Long Meadows Lookout tower
Promiser
Lookout tower
Lookout tower
Lookout tower
Lookout tower
Ranger Station
Cricket Flat
Minam
Minam Hill
Diamond Prairie
Wallowa
Sacajawea (2200)
Grange Hall
Imbler
Alicel
Lookout
Point Prom
Lookout
Grande Ronde
Wallowa Mountains
Minam River
Rock Creek
Bear Creek
Wallowa River
Bear Wallow Creek
Indian Trail Canyon
Union Pacific
Union Pacific
Mount Harris
Mount Fanny
Mount Emily
Mount Howard
Mount Morgan
Mount Ellis
Mount Ellis
Mount Ellis

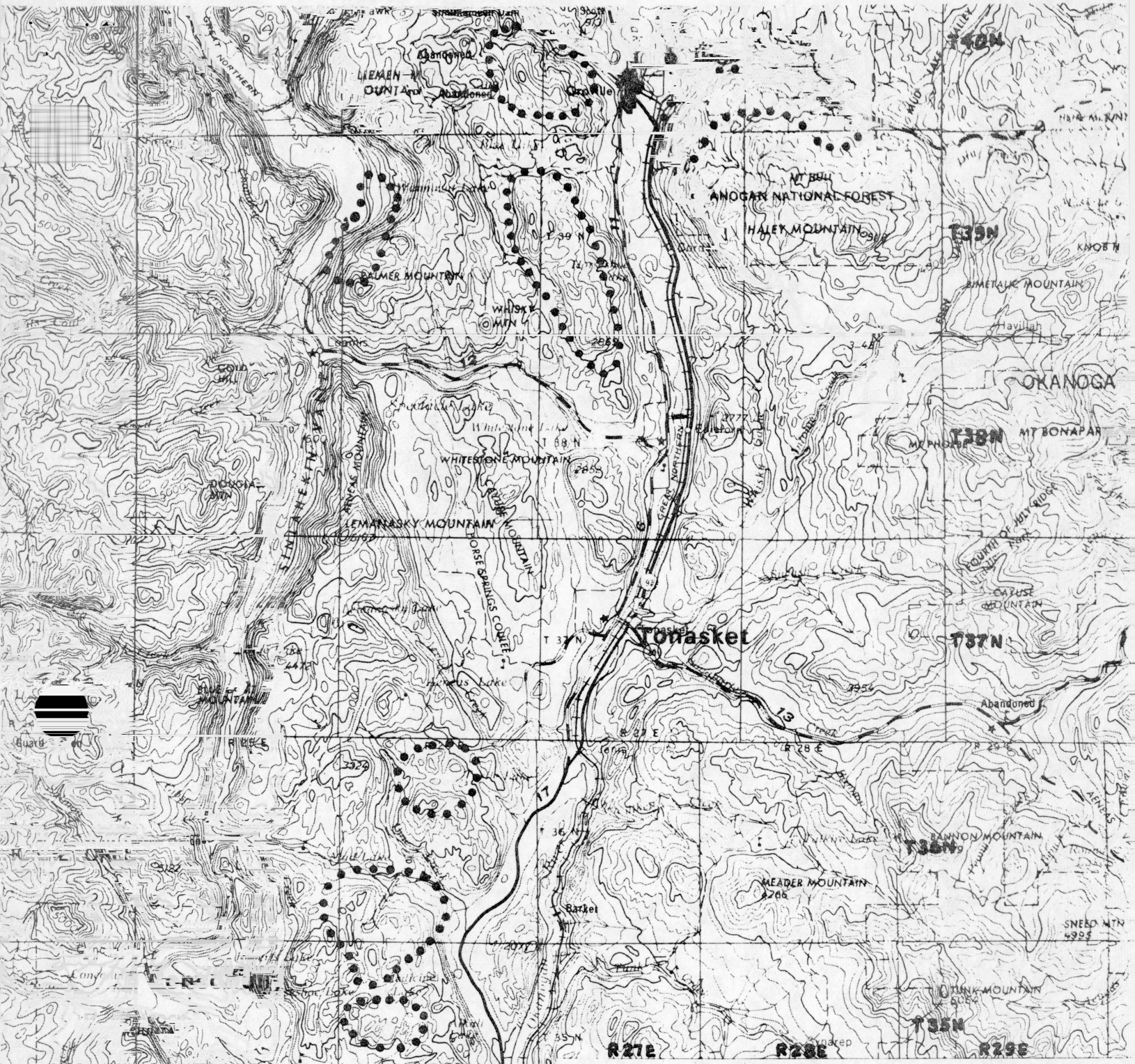

LEGEND
DOUGLAS-FIR TUSSOCK MOTH
BLUE MOUNTAIN OUTBREAK MAP #6
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
Joseph
Wallowa Lake
Wallowa Lake Guard Station
MOUNT HOWARD
Howard Power Station
SACAJAWEA PEAK
SCHNEIDER MTN.
EAST PEAK
ANEROID MOUNTAIN
Aneroid Lake
Aneroid Creek
Roles Point
SENTINEL PEAK
MOUNT NEBO
SUNRISE PEAK
MARBLE MOUNTAIN
Marble Creek
Dobbman Point
SUGARLOAF MOUNTAIN
WALLOWA COUNTY
RED MOUNTAIN
RUSSEL MOUNTAIN
Fish Lake Guard Station
GRANITE MOUNTAIN
Granite Creek
Lookout Tower
MORGAN BUTTE
MILLER BUTTE
GUMBOOT BUTTE
TYEE BUTTE
NESBIT BUTTE
Lookout Tower
Buck Lake
Coverdale Forest Camp
Cold Springs Guard Station
Homestead
Chesnimnus Creek
Chesnimnus Ridge
Hurricane Creek
Hurricane Ridge
Hendricks Ranch
Mc Cray Lookout Tower
Langrell
Halfway
Sparta Butte Ranch
Mahogany Butte
Ranch
Lick Creek
Lick Creek Ridge
Lick Creek Summit
Lick Creek Guard Station
Lick Creek Campground
Lick Creek Ranger Station
Lick Creek Ranger Station
Lick Creek Ranger Station

VICINITY MAP

DOUGLAS-FIR TUSSOCK MOTH OUTBREAK IN NORTH CENTRAL WASHINGTON




LEGEND
DOUGLAS-FIR TUSSOCK MOTH
WENATCHEE OUTBREAK
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
WENATCHEE
NATIONAL
Lake Wenatchee
Leavenworth
Cashmere
Peshastin
Winton
Chumstick
Plain
Merritt
Nason Creek
Fir Creek Recreation Area
Glacier View Recreation Area
Zanika Recreation Area
Alpine Lookout
Rock Mountain Lookout
Lake Wenatchee State Park
Dirtyface Lookout
Wenatchee Ranger Station
Tyee Mountain Lookout
Sugarloaf Peak Lookout
Flat Recreation Area
Tumwater Recreational Area
Bridge Creek Recreation Area
Power house
Fish hatchery
Lightning Creek Recreation Area
Boundary Butte Lookout
Cashmere Mountain Lookout
Icicle Lookout
Chumatick Mtn
Ingalls Creek Guard Station
Camp
Rock Creek Guard Station
Grouse Creek Rec Area
Lake Creek Recreation Area
Quarry
Cabin
Lookout tower
Ski area
Recreation Area
Camp
Lookout Tower
Cabin
Dryden
Monitor
Wenatche
MAVERICK PEAK
5340
MOUNT HOWARD
7120
MOUNT MASTIFF
6230
BOUND MOUNTAIN
ARROWHEAD MOUNTAIN
SNOWGRASS MOUNTAIN
8030
NATAPOC MTN
4185
CAPE HORN
7315
BIG JIM MOUNTAIN
7775
GRINDSTONE MTN
CHIWAUKUM MOUNTAINS
TUMWATER MOUNTAIN
ICICLE RIDGE
JACK RIDGE
CHIWAWA RIDGE
WHITE MOUNTAIN
CROOK MOUNTAIN
5720
McCALL MOUNTAIN
WHITTIER PEAK
BASALT PEAK
LABYRINTH MOUNTAIN
DIRTYFACE PEAK
6260
Poe Peak Lookout
6289
Mt David Lookout
7421
Beehive Peak
7640
7280
Boulder Peak
Cougar Mountain
THE CRADLE
6980
HARDING MTN
7140
CANNON MTN
8630
MT STUART
9415
STUART RANGE
INGALLS PEAK
7070
7290
WEDGE MTN
4735
5029
CHELAN COUNTY
T 16 E
R 17 E
R 18 E
R 15 E
R 14 E
T 27N
T25N
T24N
T 23 N
T 22 N
T 21 N
T 20 N
T 29 N
RIDGE
Ingalls Creek
Chiwaukum Creek
Icicle Creek
Tumwater Canyon
Mission Creek
Peshastin Creek
Wenatchee River
Nason Creek
Chiwaukum Creek
Fish
Arden
Franch C
Camas Land



LEGEND

DOUGLAS-FIR TUSSOCK MOTH

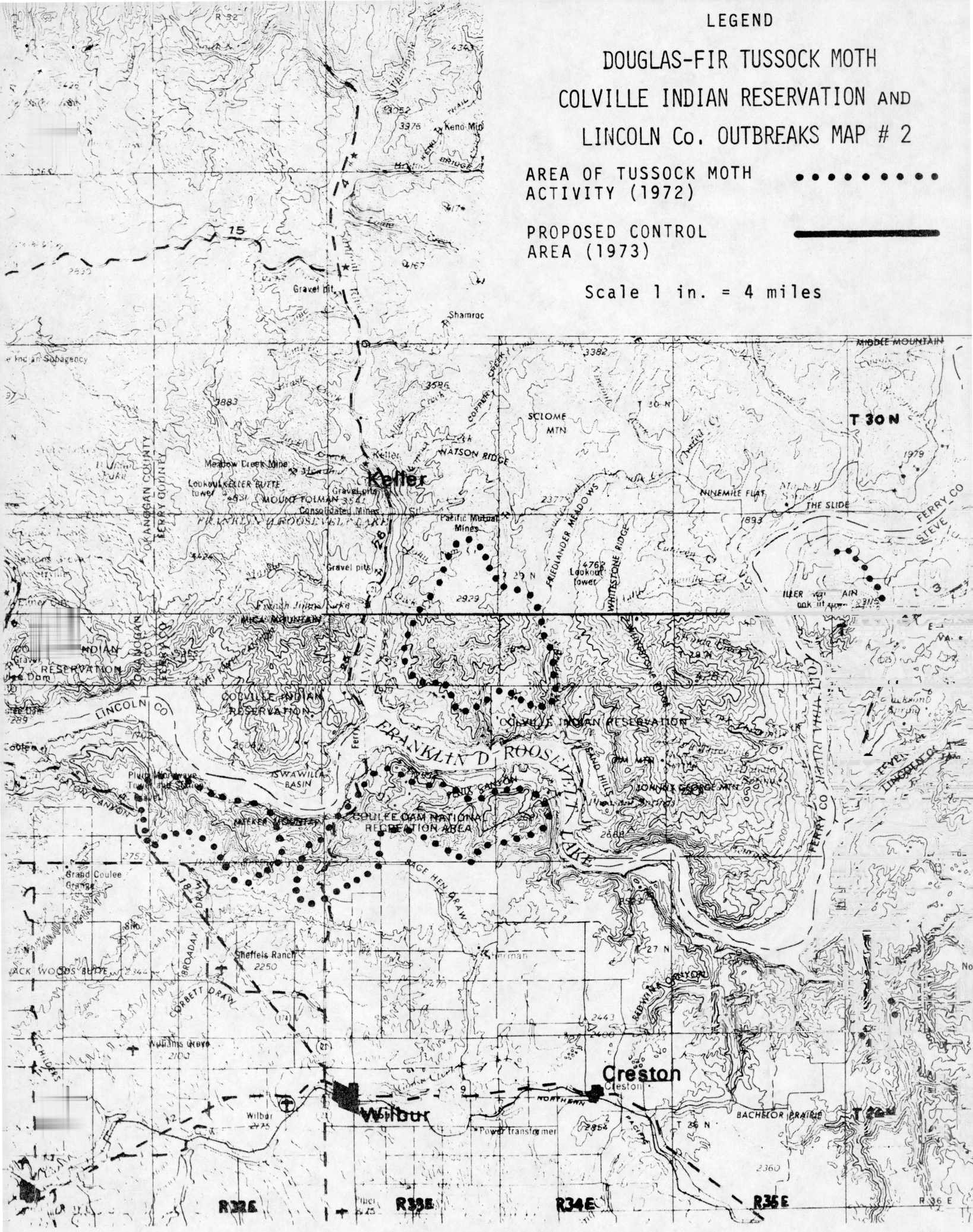
OKANOGAN COUNTY OUTBREAK

AREA OF TUSSOCK MOTH ACTIVITY (1972) ••••••••

PROPOSED CONTROL AREA (1973) ————

Scale 1 in. = 4 miles

LEGEND
DOUGLAS-FIR TUSSOCK MOTH
COLVILLE INDIAN RESERVATION AND
LINCOLN Co. OUTBREAKS MAP #1
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
COLVILLE
Gravel pits
ARMSTRONG MOUNTAIN
Lookout tower
SQUAW MOUNTAIN
Nespelem
Mines
Gravel pit
Colville Indian Subagency
DOUGLAS COUNTY
OKANOGAN COUNTY
Abandoned
ALAMEDA FLAT
Belvedere
Tower abandoned
Knotzville
Elmer City
COLVILLE INDIAN RESERVATION
Gravel
Coulee Dam
DOUGLAS CO.
GRANT CO.
LINCOLN CO.
Grand Coulee Dam
North Dam
Grand Coulee
Electric City
BARKER CANYON
Plutt Microwave Tower and Station
Gravel
ISWAWILA BASIN
COULEE RECRE
Grand Coulee
T32N
T30N
T29N
T28N
R28E
R29E
R30E
R31E
R32E


LEGEND
DOUGLAS-FIR TUSSOCK MOTH
COLVILLE INDIAN RESERVATION AND
LINCOLN Co. OUTBREAKS MAP # 2
AREA OF TUSSOCK MOTH ACTIVITY (1972)
PROPOSED CONTROL AREA (1973)
Scale 1 in. = 4 miles
Keller
Wilbur
Creston
Grand Coulee
Gravel pit
Shamrock
Meadow Creek Mine
Consolidated Mines
Pacific Mutual Mines
SCLOME MTN
WATSON RIDGE
NINEMILE FLAT
THE SLIDE
MIDDLE MOUNTAIN
FRIEDLANDER MEADOWS
WHITESTONE RIDGE
MICA MOUNTAIN
COLVILLE INDIAN RESERVATION
FRANKLIN D ROOSEVELT LAKE
COULEE DAM NATIONAL RECREATION AREA
SWAWILLA BASIN
JOHNNY GEORGE MTN
SAGE HEN DRAW
BROADAX DRAW
CORBETT DRAW
REDWIN CANYON
BACHELOR PRAIRIE
OKANOGAN COUNTY
FERRY COUNTY
LINCOLN CO
T 30 N
T 29 N
T 28 N
T 27 N
R32E
R33E
R34E
R35E
R36E